

STANDARDIZATION  
OF  
POLLUTION TESTS IN IEC TC 42

IEC TC 42, High Voltage Testing Techniques, has adopted the following clauses for contamination testing. These have been approved to be sent out to the National Committees under the six-months rule.

3.4 Artificial pollution tests

Artificial pollution tests are intended to provide information on the behaviour of external insulation under conditions simulating pollution in service.

The basic objective is usually to verify that the test object will withstand a specified amount of pollution at a given test or operating voltage.

For comparison tests and for research, the objective may be either to determine the degree of pollution that the test object can withstand with a given probability at a given test voltage, or to determine the withstand voltage for a specified degree of pollution. For comparison tests, the former procedure is preferable.

The procedure to be adopted must give reproducible results, taking into account the statistical nature of the flashover mechanism.

The result of an artificial pollution test is dependent mainly on the following factors:

- the installation of the test object
- the procedure for applying the pollution
- the amount, conductivity and distribution of the pollution
- the amount of moisture deposit
- the manner in which the test voltage is applied.

3.4.1 Test procedures

3.4.1.1 Installation

The test object should be tested in a position (horizontal, vertical or inclined) corresponding to actual working conditions. The clearance to entraneous structures (see Clause 3.1) need not exceed 1.0 S and may even be reduced below this, without affecting the validity of results, provided risk of flashover of the clearance is avoided.

The insulator shall be in thermal equilibrium with the air in the chamber at the start of the test. The ambient temperature at the start of the test shall be not less than 5°C or greater than 30°C.



### 3.4.1.2 Application of pollution

There is at present no standard or universally accepted artificial pollution test procedure but at least two different methods have been developed and are already in use to determine the performance of insulators subjected to pollution. The essential requirement is the repeatable production of various degrees or "severities" of pollution; this may be measured in terms of specific resistance or of some directly related parameter. Determination of performance, on the application of a suitable test voltage, is usually expressed in terms of the pollution severity.

The two techniques may be broadly described as the saline fog method and the predeposited pollution method:

#### a) Saline fog method

This is generally carried out by placing the test object in a special room which can be filled with a fog from a salt solution. The effect of simultaneously applying an appropriate test voltage while these conditions are maintained for a period of time are then evaluated.

In Appendix 1A, details are given of one saline fog technique.

#### b) The predeposited pollution method

The pollution is applied in a layer having approximately uniform thickness. It is usually a mixture of water, a non-conducting binding medium (for instance kieselguhr or kaolin), and a medium giving a controlled resistivity (for instance a metallic salt). The voltage is applied and the test object is wetted continuously with a fine water spray. Alternatively, the applied layer is so constituted that it retains sufficiently moisture for the duration of the test.

Procedure suitable for carrying out the predeposit pollution method is given in Appendix 1B.

### 3.4.2 Application of test voltage

Two procedures are in use for the application of voltage:

- a) A constant voltage is applied to the artificially polluted test object for a specified time (generally in the region of 30 - 60 minutes) or until flashover occurs. In the case of the predeposited pollution method, the test may also involve the drying period which follows cessation of the wetting process.
- b) A voltage of a specified value is applied and then raised at a specified low rate until flashover occurs. Several applications are made from which an average flashover voltage and a standard deviation may be determined.



Note: A flashover test with a rapidly increased applied voltage does not reproduce the same physical phenomena, involving the important thermal effects, associated with the application of a constant voltage (as in service).

## APPENDIX 1A

### DETAILS OF SALINE FOG TECHNIQUES

#### 1. Cleaning

Before the test object is tested for the first time, the metal parts and cement should be painted with a corrosion-resistant paint, if found to be necessary, to ensure that no corrosion products contaminate the insulating surface during testing.

The test object should be washed with a suitable detergent to remove every trace of grease. Then it should be rinsed thoroughly with water of a high resistivity (more than 20  $\mu\text{m}$ ) to remove the remaining traces of any ionising material.

The surface of the test object is deemed to be sufficiently clean and free from any fat, grease, or any residuals if large continuous wet areas are observed.

#### 2. Salt solution

The salt solution shall be made up to the required concentration expressed in g/l of solution from salt (NaCl) and mains water. It is recommended that the concentration be measured either by means of a hydrometer or a conductivity bridge with a correction for temperature.

It is recommended that the salt-solution concentration used should be one of the values: 2.5, 3.5, 5, 7, 10, 14, 20, 28, 40, 57, 80, 112, 160 and 226 g/l. The use of intermediate values may be justified in distinguishing between insulators of similar performance if their withstand salinities are low, or if carrying out a larger number of tests than that specified is considered justifiable.

The maximum permissible error in salt concentration is  $\pm 5\%$  of the nominal value.

#### 3. Spraying system

The fog is produced in the test chamber by means of the specified number of jets (Figure 4), which produce a fine mist of the solution by a stream of compressed air flowing across the solution nozzle. The tolerances on the air and solution nozzles are as follows: internal  $\pm 0.02$  mm, external  $\pm 0.05$  mm. The ends of both nozzles shall be square-cut and polished. The end of the solution nozzle shall



lie on the axis of the air nozzle to within  $\pm 0.05$  mm and the maximum distance between the axes of these tubes shall be 0.05 mm. The pressure of the water shall be adjusted so that the flow of solution through each nozzle shall be 0.5 l/min.  $\pm 10\%$  for the period of the test, and the tolerance on the total flow to all jets shall be  $\pm 5\%$  of the nominal value.

Note that these requirements of the jet system for producing a salt fog differ considerably from those of nozzles used for wet tests.

The jets shall be in two pairs of columns parallel to and on opposite sides of the insulator which shall have its axis in the same plane as the columns, i.e. a vertical insulator will be tested with vertical columns and a tension insulator with horizontal columns. In the case of an inclined insulator the plane containing the insulator and the columns shall intersect the horizontal plane in a line at right angles to the insulator axis. The distance between the jets and the insulator axis shall be  $3 \text{ m} \pm 5 \text{ cm}$  for test voltages up to about 600 kV. For higher voltages larger spacings will be required. The jets shall be spaced at 0.6 m intervals, each jet pointing at right angles to the column axis towards its counterpart on the other column and within an angle of  $1^\circ$  to the plane of the sprays. This aim can be achieved for vertical jet columns by lowering the solution nozzle passing water through the air nozzle and directing it towards the opposing jet afterwards raising the water nozzle to the operating position. 10 or more jets per column are desirable, but as few as 5 are acceptable for insulators up to about 150 kV system voltage. The mid-point of the insulator shall be preferably in line with the mid-points of the columns of jets. Both columns shall extend beyond the insulator at both ends by at least 0.6 m. For vertical insulators, the bottom jets shall be 0.6 m above the floor of the chamber.

The jets shall be supplied with filtered, oil-free air at a pressure of  $7.0 \text{ kg/m}^2$  (4%).

#### 4. Test procedure

The prepared insulator is installed in its test position in the test chamber and energized before the spray jets are started.

The salt-solution pump and air compressor are switched on, and the test is deemed to have started as soon as the compressed air has reached the normal operating pressure at the jets.

The object of an individual test is to determine the salinity of the fog which the insulator will endure without flashover for 60 minutes. A test with any one value of salinity therefore ends after 60 minutes or when the insulator flashes over.



## APPENDIX 1B

### DETAILS OF PREDEPOSITED POLLUTION METHOD

#### 1. Cleaning and Installation

The same rules for cleaning and installation apply as in Appendix 1A. The insulators are then coated with a contaminating slurry and tested as indicated under 3 or 4 below.

#### 2. Measurement of Pollution

The degree of contamination of the insulator surface can be specified in one or more of the following three ways.

- a. The resistivity of the contaminating slurry.

This is best measured with a conductivity bridge.

- b. The surface resistivity of the insulating surface.

This can be measured by applying a voltage of at least 2 kV/meter of total leakage path of the test object and measuring the leakage current of the test object. From these measurements the resistivity is determined. The lowest surface resistivity of a uniformly-distributed layer is then determined by dividing the insulation resistance by the form-factor  $f$  of the test object:

$$f = \int_0^{x_t} \frac{dx}{b(x)}$$

$x$  = leakage path

$x_t$  = total leakage path

$b(x)$  = circumference of the insulator

The formula is preferably evaluated by graphical integration. The surface resistivity  $\rho_s$  at the temperature  $t$  is to be referred to a reference temperature  $t_0 = 20^\circ\text{C}$ , according to:

$$\rho_{sto} = \rho_{st} \left( 1 + 0.02 (t - t_0) \right)$$

- c. The equivalent salt deposit on the insulating surface may be determined by washing the pollution off of a specified area and dissolving it in distilled water. The amount of salt yielding the same conductivity when dissolved in the same amount of distilled water is considered as the equivalent.



### 3. Coating of the Test Object

A suspension is prepared which normally has the following composition:

100 g kieselguhr (Diatomaceous earth, diatomite)

10 g highly dispersed silicium dioxyd, particle  
size 2 - 20 nm (Aerosil) as thickening matter

1000 g water

Any other suspension or colloidal solution may be also used, if it has the same characteristic effects. In this case, the deposit on the surface of the test object should absorb about the same amount of water as when aerosil is used.

A specified resistivity of the suspension is obtained by adding a suitable amount of saturated calcium-chloride solution ( $\text{CaCl}_2$ ) or sodium chloride ( $\text{NaCl}$ ). For classifying the degree of pollution, the following values can be chosen with a tolerance of  $\pm 15\%$  and referred to  $20^\circ\text{C}$ .

Suspension resistivity, $\Omega\text{m}$	6.7	3.3	1.7	0.83
Layer resistivity, $\text{k}\Omega/\text{m}$ (completely wet)	200	100	50	20

The coating of the test object shall be effected by spraying this suspension on the clean surface of the test object using one or more spray nozzles, or suitable type of paint spray gun. The resulting layer should be so far as possible uniformly-distributed over the whole surface of the test object.

The coated test object should be uniformly wetted over its whole surface within about 15 to 30 minutes, using a steam fog generator or alternatively employing for nozzles such as shown in Figure 4 and 5 inserted in an arrangement corresponding to Figure 6. Compressed air flows through the nozzles and sucks normal tap water from a container. Each nozzle has its own open container so that the height H between the nozzle and the container remains constant. With constant air pressure, the quantity of fog produced by each nozzle is the same. The quantity of water can be varied by changing either the height H or the air pressure.

Columns with nozzles spaced at equal distances are placed around the test object. The progress of the wetting process is to be checked by measuring the insulation resistance as described in Item 2b above until its minimum value is achieved.



#### 4. Test Procedure

The test voltage should be applied to the completely-wetted insulation when the minimum layer resistivity is achieved and the wetting process is continued as previously. The adjusted fog intensity should be kept constant during the test. Care must be taken to avoid water dropping from the sheds of the test object. The time of application of the test voltage should be at least 15 minutes.

If no dropping occurs, the test can be repeated with the same test object 4 times after drying after each single test. But only the first measured layer resistivity should be taken as reference.

#### 5. Note

A variation of this method, described below, which does not require a fog spray is also in use. Acceptance of this is under consideration by TC 42.

A solution of a specified resistivity is prepared with the following composition:

20 g	pyrogenic silica ( $\text{Si O}_2$ )
1 g	photographic wetting agent
1000 g	water

Sodium chloride to obtain resistivity as listed above.

This solution is flowed on to the test object by means of an annular arrangement of nozzles each having an oval orifice approximately  $1/4'' \times 1/8''$ . The nozzles are directed inward with a tangential component so as to swirl the solution around the contours of the test object. This flow coating apparatus is moved slowly from top to bottom of the test object while the solution is pumped through the nozzles thoroughly wetting all of the insulator surfaces to the point of run-off.

A sufficient period (about 5 minutes) is allowed for dripping to stop and the coating to stabilize. The voltage is then applied and raised rapidly to the test level where it is held for a period of at least 15 minutes or until flashover occurs. For each test the test object must be washed, dried and recoated.



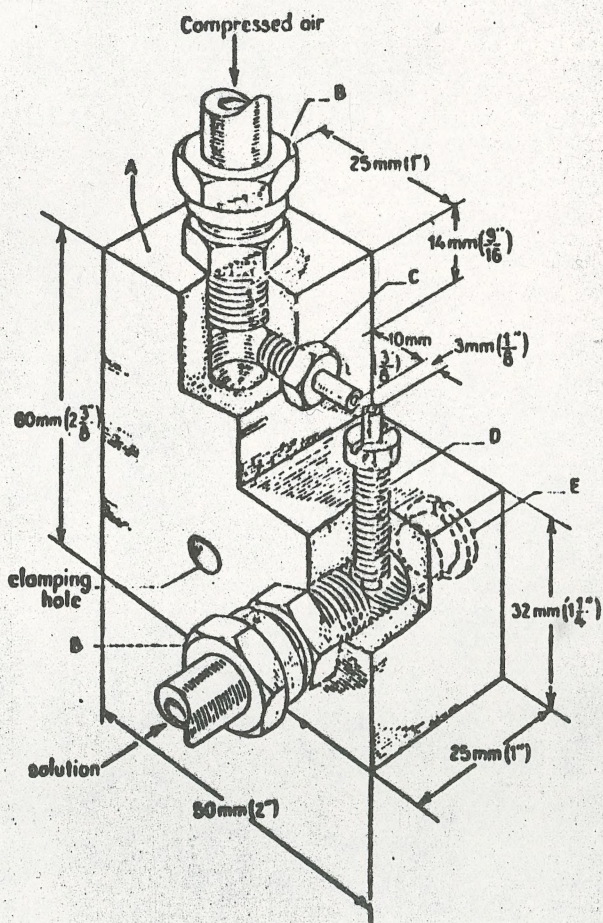
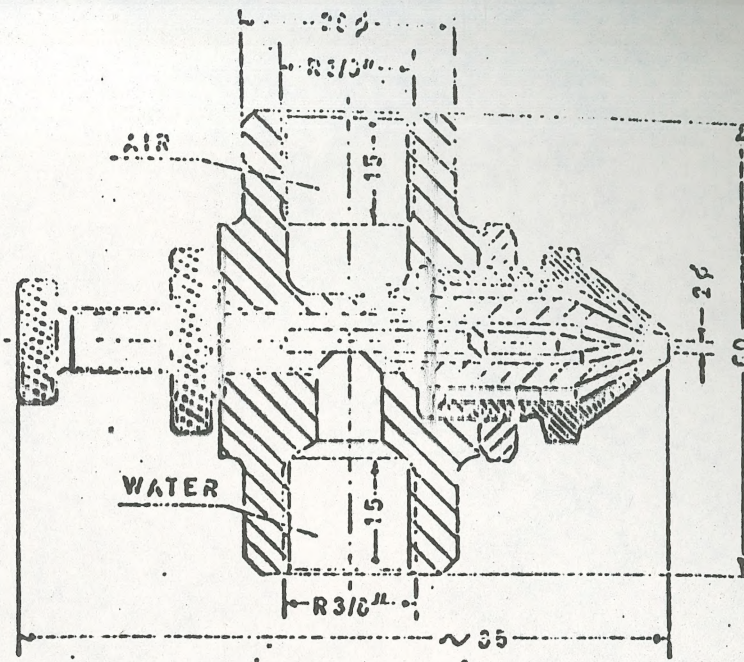
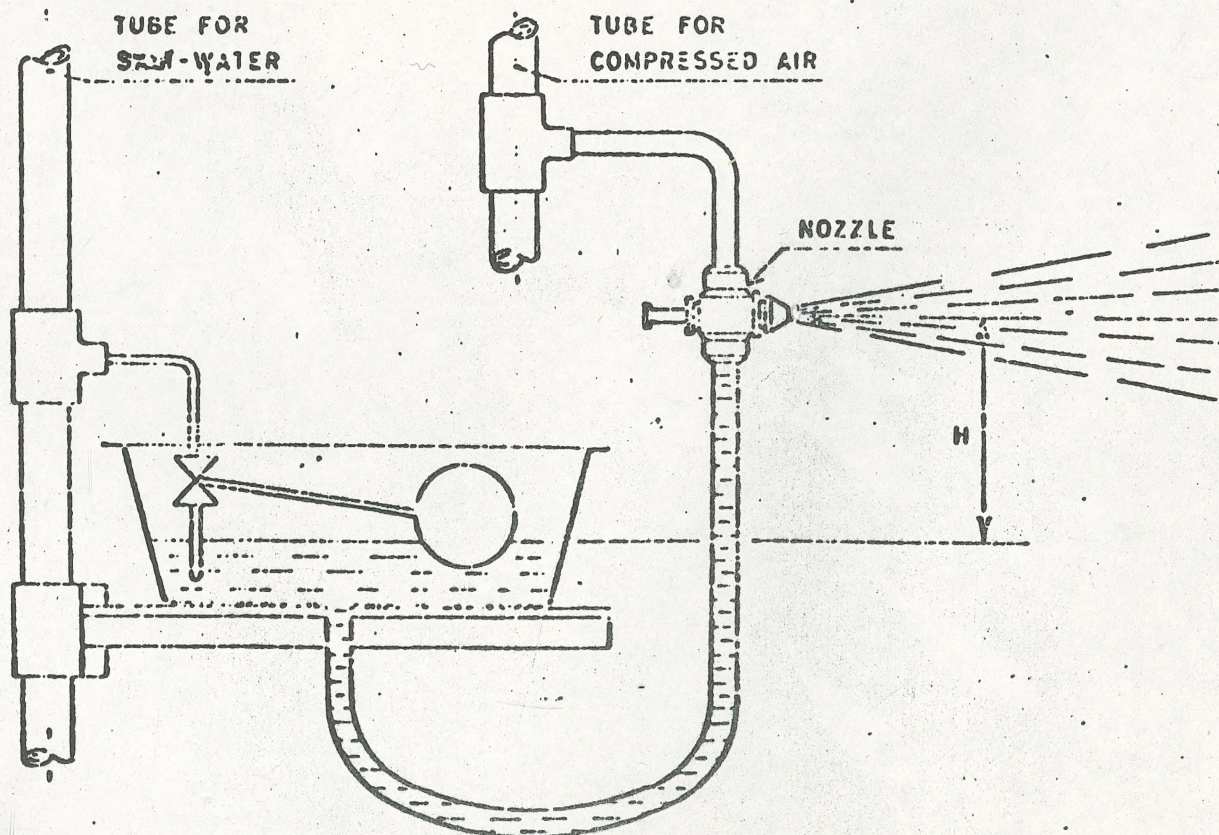


Fig. 4





**FIG. 5** LECHLER NOZZLE TYP Dr 112



**FIG. 6** ARRANGEMENT FOR PRODUCING FOG